INFOTOX (Pty) Ltd

2001/000870/07

Retrieval and scientific interpretation of ecotoxicological information

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Project conducted on behalf of

The South African Wood Preservers Association

Health Risk Assessment and Management of Chromated Copper Arsenate Through the Product Value Chain

Document No 110-2022 Rev 8.0

Compiled by

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8 May 2024

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8 May 2024

Expertise and Declaration of Independence

This report was prepared by INFOTOX (Pty) Ltd ("INFOTOX"). Established in 1991, INFOTOX is a professional scientific company, highly focused in the discipline of ecotoxicological risk assessment. Both occupational and environmental human health risks, as well as risks to ecological receptors, are addressed.

Dr Willie van Niekerk is a Qualified Environmental Professional (Environmental Toxicologist QEP) (No 07960160), certified by the Institute of Professional Environmental Practice in the USA, and a registered Professional Natural Scientist (Pr Sci Nat, Environmental Science) (No 400284/04) (http://www.sacnasp.org.za/).

The QEP certification is the first and only credential of its kind in the USA. It is a multi-disciplinary, board-certified scientific credential that requires environmental professionals to view "the big picture" and to have the skills and knowledge to resolve "real world problems". It is international in scope and has received accreditation by the Council of Engineering and Scientific Speciality Boards (CESB). The CESB is an independent organisation that accredits engineering, scientific, and technology certification programmes (www.ipep.org). The QEP certification is now recognised by the Board for Global EHS Credentialing.

Dr Van Niekerk has extensive experience in the assessment of human health risks associated with hazardous chemicals, including arsenic and chromium. He has been involved in many GHS classifications for wastes and materials in the metallurgical industry.

He has served as expert witness in a number of litigation cases pertaining to human exposure to hazardous chemicals and potential liability of companies.

Dr Van Niekerk is a member of the Toxicology Society of South Africa (TOXSA) and a member of the National Association for Clean Air (NACA).

Dr Marlene Fourie has BSc and Hons BSc degrees (Biochemistry) from the University of Stellenbosch and MSc and PhD degrees (Reproductive Biology: Andrology) from the University of Pretoria. Her PhD degree was obtained in 1999 in the field of environmental toxicants affecting the male reproductive system through hormone-mimicking mechanisms which, amongst other adverse health effects, are associated with exposure to dioxins. During her tenure as Medical Natural Scientist at the Andrology Unit, Department of Urology, University of Pretoria and the Pretoria Academic Hospital from 1987 to 2001, she was successful in publishing articles in scientific journals and presented her research at national and international scientific conferences. She joined INFOTOX as a Medical Biological Scientist in 2001. Shortly after, Dr Fourie enrolled for an MSc-degree in Epidemiology from the University of Pretoria, attending courses, gathering data, conducting statistical analyses of data and interpreting statistical results for her Master's Thesis on a potential carcinogen in the metal processing industry in the USA and South Africa. She obtained the MSc degree in 2009.

Dr Fourie has conducted many health risk assessments and projects relating to the health impacts of environmental pollutants, and the health status of communities while employed at INFOTOX. She has wide experience in GHS classifications and the compilation of safety data sheets. Dr Fourie successfully completed the United Nations Training Institute and Research (UNITAR) GHS e-Learning course. She is a registered Professional Natural Scientist (Pr Sci Nat, Toxicological Science, No 400190/14) at the South African Council for Natural Scientific Professions (SACNASP). Dr Fourie is a member of the Toxicology Society of South Africa (TOXSA).

This specialist report was compiled for the South African Wood Preservers Association. We do hereby declare that we are financially and otherwise independent of the South African Wood Preservers Association.

Signed on behalf of INFOTOX (Pty) Ltd, duly authorised in the capacity of Managing Director:

Willem Christiaan Abraham van Niekerk

8 May 2024

Applicability

This INFOTOX report is applicable to chromated copper arsenate wood preservative through the value chain, from manufacturing up to its end use in timber preservation in the environment. The scientific contents of this report are applicable to all CCA formulations manufactured in South Africa and conforming to SANS 673:2017 (Ed 3.04), "*Mixtures of copper-chromium-arsenic compounds for timber preservation*", otherwise referred to as the category of chromated arsenicals.

This report was prepared for the South African Wood Preservers Association ("SAWPA") for the purpose of making the scientific information accessible to members of SAWPA in the CCA industry, as well as to the general public. The scientific information applies directly to the manufacturers of CCA product trade names and L registration numbers as listed below:

i) Arxada, trading as Arch Wood Protection (SA) (Pty) Ltd (Company Reg No 1996/003175/07). CCA product details: TANALITH® C Oxide Liquor (DALRRD Reg No L3150).

ii) Dolphin Bay Chemicals (Pty) Ltd (Company Reg No 2003/031169/07). CCA product details: PERMACURE Oxide Liquor Concentrate ("PERMACURE") - (DALRRD Reg No L5732) and CELCURE OXIDE (DALRRD Reg No. L3097).

iii) Timberlife (Pty) Ltd (Company Reg. No. 2000/017132/07). CCA product details: CHROMAC (DALRRD Reg. No. L4444).

WCA van Niekerk PhD QEP (USA) Pr Sci Nat (Environmental Science)
Managing Director

SHORT SUMMARY OF RISK ASSESSMENT REPORT OUTCOME

Compiled and inserted by:

WE Conradie
Technical Director
TimberLife (Pty) Ltd

The risk assessment done shows that CCA poses no direct threat or risk to the general public. Exposure to the CCA chemicals (i.e. CCA concentrate and/or diluted treating solution) is restricted to personnel involved in (i) the manufacture of, and (ii) the application of these wood preservatives at NRCS approved and well-regulated and certified industrial treatment plants. Potential risk of direct exposure to CCA chemicals during the manufacture and application thereof is manageable through the correct handling and use by properly trained people wearing the appropriate PPE. Because CCA fixes chemically with the cellulose and lignin of the wood (complete fixation is generally achieved within about 3 to 4 days after impregnation), potential release of the CCA chemicals from the treated timber thereafter is insignificant. Therefore, after fixation of the CCA chemicals within the wood structure is complete, and the hexavalent chromium [(Cr (VI)] has been reduced to trivalent chromium [(Cr III)] during the process, CCA-treated timber is safe to handle and use. (Please note that trivalent chromium is not a CMR substance). No long-term health effects have been reported when CCA-treated timber is used under normal conditions of good building practice. CCA has also been classified as a GHS hazard category 2 "Restricted Agricultural Remedy" due to its acute inhalation toxicity and may therefore (i) only be sold to and used by registered Pest Control Operators for industrial application and (ii) only be applied as directed on the label. Therefore, when manufactured and used in a controlled manner for the purpose it is meant for, there is no need for CCA to be phased out. It is also important to note that (i) CCA has been used as a heavy duty, wide-spectrum wood preservative since the 1930's and (ii) in terms of both cost and efficacy, CCA is still the most effective waterborne wood preservative available.

Executive Summary

In a document circulated to "*All Regulatory Holders*" on 14 April 2022, the Registrar of the Department of Agriculture, Land Reform and Rural Development ("Registrar" and "The Department") stated his intention to prohibit the use of active ingredients and their formulations that meet the criteria of carcinogenicity, mutagenicity, and reproductive toxicity (CMR) categories 1A or 1B according to the Globally Harmonized System of Classification and Labelling of Chemicals ("the GHS").

In a subsequent letter to the South African Wood Preservers Association, dated 3 August 2022, the Registrar indicated that a change of the policy position on pesticide management in South Africa will not be considered, but an evaluation of whether there is an exceptional situation where the risk of such products, when used according to label instructions could be manageable, may be allowed.

In addition, the Regulations for Hazardous Chemical Agents ("HCA"), 2021, made under the Occupational Health and Safety Act, 85 of 1993 impose obligations to classify products under the GHS, which obligations come into force on 29 September 2022. This report is also prepared in compliance with those obligations.

This INFOTOX report deals with health risks and management of risks associated with chromated copper arsenate (CCA) wood preservative through the value chain, from manufacturing up to its end use in timber preservation in the environment. The report considers whether there are exceptional circumstances that would permit the use of CCA because, when used according to the label instructions, its risk to human health is trivial and exempted from further consideration.

An overview of various pieces of legislation that control potential environmental health risks relating to the manufacturing and use of CCA in wood preservation is presented. A range of South African National Standards dealing, amongst others, with health and safety and control standards for the wood treatment process, are summarised, and placed in context with international best practice. Note that the constituents of CCA are not on the list of prohibited chemical agents in the Regulations for HCAs. Instead, the constituents of CCA are assigned occupational exposure limits in the Regulations.

This INFOTOX report follows on a 2014 publication on arsenic-related cancer risks at children's playsets constructed with CCA-treated wood. The report was initiated following a voluntary restriction by registrants on the use of CCA-treated wood at children's playgrounds. The US Environmental Protection Agency ("USEPA") never banned the use of CCA and constructions already in place were allowed to remain. INFOTOX indicated that there was little scientific evidence of health risks at the time of implementing the voluntary restriction, and that decisions were taken by invoking the precautionary principle. INFOTOX concluded on the basis of a review of subsequent publications that there was a coherent set of studies that indicated insignificant cancer risks associated with exposure to arsenic at CCA playgrounds. The USEPA is currently in the process of re-registering pesticides, including CCA, and in the supporting documents that INFOTOX considered there are no indications of an intention to prohibit the use of CCA in wood treatment in the USA.

Restrictions on the use of CCA-treated wood in residential constructions have been instituted in the European Union ("EU") through the Registration, Evaluation, Authorisation and Restriction of Chemicals ("REACH"), also based on invoking the precautionary principle. Use of CCA in timber treatment has not been banned in the EU and, similar to the position in the USA, there has not been an instruction to remove CCA-treated wood structures already in use in residential applications.

Further, there are well supported scientific reasons why public health risks associated with CCA-treated wood are insignificant. CCA in wood following impregnation is no longer a mixture of chemicals (chromium, copper and arsenic compounds), but due to chemical reactions, the CCA is fixed in a complex structure that is referred to as a "preparation". Hexavalent chromium in CCA, which is carcinogenic and mutagenic, is reduced to trivalent chromium in the wood treatment process. Trivalent chromium is not a CMR substance. INFOTOX conducted health hazard classifications for CCA-treated Pine and for Eucalyptus wood according to the GHS. Due to the fact that CCA is fixed in the wood, total concentrations of the individual chemicals are not relevant in the GHS classification, but only the small fractions of these chemicals that can be released from the fixed CCA structure have to be considered. This is in accordance with GHS classifications for materials that can be regarded as preparations, such as metal alloys, soil and sand, natural rocks, and metallurgical slag. INFOTOX showed that the CCA-treated wood examples did not classify as hazardous for any of the health endpoints that are considered in the GHS.

The initiative to limit public exposure to chemicals that meet the criteria of CMR categories under the GHS requires careful assessment. Note that at this point the argument is about hazards in the CMR category according to the GHS, but the deciding factor should be demonstration of the likelihood of risk. The fact that a material or product contains arsenic does not, itself, mean that there is a risk to the public. The toxicity of arsenic is not argued, but an intact route of exposure to the receptor must be available in order for the hazard to result in a health risk. There is no purpose in removing a material or product from society if, firstly, its presence does not indicate a route of exposure and, secondly, such removal will not reduce risk in any way.

Multiple credible scientific references have confirmed that the very small potential exposure to arsenic from contact with CCA-treated wood is far below and indistinguishable from the background arsenic levels in food and drinking water. Considering that exposure of the general population to arsenic is primarily through water and food, reducing health risks through this anticipated prohibition by the Registrar should be best achieved through reducing dietary exposure to arsenic, if possible

Any decision to implement precautionary measures in the public interest needs to be justified by more than pointing at the possibility that a risk may exist. That is particularly so where the public benefit of using the product in question for protection of wood in construction materials is undisputed. The decision to prohibit manufacture and use of a formulation such as CCA requires evidence that public exposure to arsenic will decrease because of this prohibition, and most importantly, a structured and transparent procedure must exist for quantifying this evidence. It is clear from this INFOTOX review of a large volume of scientific information on this topic that evidence of an increase in public health risks as a result of the use of CCA in timber is lacking, and a decrease in public exposure to arsenic as a result of prohibiting the use of CCA in timber treatment will be impossible to demonstrate.

Evaluation of the use of CCA as a timber preservative in the EU, USA and elsewhere, and assessment of multiple scientific reports on the matter, confirm that CCA represents **an exceptional case** in considering prohibition in its use because of CMR constituents. CCA is a superior formulation in preserving wood in various outdoor applications and is effective for over 30 years. As described in South African National Standard SANS 1288, economic losses due to adverse impacts on wood in the absence of treatment with a preservative are considerable. SANS 1288 also stated that some of the treatment formulations are ineffective for the given hazard conditions. Considering the implausible notion that prohibiting CCA in wood treatment would lead to health benefits, we respectfully submit that it will not be in the public interest to prohibit the use of CCA in timber treatment. It should therefore be regarded as an exceptional case and its use should not be prohibited.

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1 Points of departure

In a document circulated to "*All Regulatory Holders*" on 14 April 2022, the Registrar of the Department of Agriculture, Land Reform and Rural Development ("Registrar" and "The Department") refers to an assessment that was carried out at the international level to determine risks to human health due to exposure to active ingredients and their formulations that meet the criteria of carcinogenicity, mutagenicity, and reproductive toxicity (CMR) categories 1A or 1B according to the Globally Harmonized System of Classification and Labelling of Chemicals ("the GHS"). The Department then stated that "*the assessment identified the need to reduce risks to human health associated with such products*".

The Registrar stated his intention to "*prohibit the use of ingredients and their formulations that meets* (sic) *the criteria of CMR categories 1A or 1B of the GHS as from 01 June 2024*".

1A stands for chemical substances for which there is scientific evidence based on humans that the substance is carcinogenic, mutagenic or reprotoxic; 1B stands for chemical substances for which there is scientific evidence based on animals that the substance is carcinogenic, mutagenic or has reproductive toxicity.

In a subsequent letter to the South African Wood Preservers Association, dated 3 August 2022, the Department stated that *"(T)he position to phase-out GHS 1A and 1 B products that fit the CMR criteria by 1 June 2024 is guided by the Pesticide Management for South Africa, 2010. The draft agricultural remedy regulations published in June 2021 for gazette amongst other is to implement the policy decision already taken in 2010. It should therefore be noted that, the additional comments, we are seeking* [sic] *is not for the change of the policy position, but rather to consider whether there is an exceptional situation where the risk of such products, when used according to label instructions could be manageable*."

This INFOTOX report deals with health risks and management of risks associated with chromated copper arsenate (CCA) wood preservative through the value chain, from manufacturing up to its end use in timber preservation in the environment. The report considers whether there are exceptional circumstances that would permit the use of CCA because, when used according to the label instructions, its risk to human health is trivial and exempted from further consideration.

In addition, the Regulations for Hazardous Chemical Agents, 2021, made under the Occupational Health and Safety Act, 85 of 1993 (discussed in more detail below) impose obligations to classify products under the GHS, which obligations come into force on 29 September 2022. This report is also prepared in compliance with those obligations.

2 Deployment of this INFOTOX document

This INFOTOX report covers various aspects of the study in logical sections, as outlined below:

Section 1 states the intention of the Department to prohibit the use of ingredients and their formulations that meet the criteria for CMR categories in a notice dated 14 April 2022 ("Notice"). The Notice logically defines the point of departure for this INFOTOX study.
Section 3 provides the status of health-risk information relating to CCA-treated wood, based on a previous INFOTOX report (Van Niekerk and Fourie 2014), with supplementary information.

Section 4 explains regulatory context, specifically with regard to regulation of the CCA manufacturing processes and the wood treatment processes specified by the Regulations for Hazardous Chemical Agents, 2021, as governed under the Occupational Health and Safety Act (Act no 85 of 1993), Department of Employment and Labour.

Section 5 provides information on chemical constituents of CCA and describes the manufacturing process.

Section 6 describes the timber treatment process, and quality and safety control standards that have to be complied with.

Section 7 refers to the European Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), and describes how permissible CCA timber treatment products and restrictions relate to the South African situation.

Section 8 provides background information on why CCA-treated timber products should not be evaluated as a mixture of chemicals in hazard assessment, but as chemical preparations.

Section 9 describes the concept of bio-accessibility and the significance thereof in human exposure and health risk assessment.

Section 10 presents human health hazard classifications of two typical CCA-treated timber products according to the GHS.

Section 11 provides a brief discussion on the current status of CCA as a wood preservative in North America.

Section 12 concludes with notes on the rationale for invoking the precautionary principle.

Section 13 summarises conclusions.

Section 14 lists the scientific literature references that were consulted in compiling this document.

3 Status of health risk information

3.1 Scientific data considered up to 2014

INFOTOX published a report on health risks of children associated with exposure to CCA at playgrounds in January 2014 (Van Niekerk and Fourie 2014). The key findings of the INFOTOX report, based on a comprehensive narrative literature review, and pertinent supplementary information, are presented in this section of the current INFOTOX report.

INFOTOX was in agreement with Read (2003) in that, at the time of publication in 2003, research reports had been inconclusive as to whether exposure to arsenic from CCA-treated structures at playgrounds posed a significant health risk to children. That is probably why regulators did not instruct the removal of existing CCA-treated structures in countries where restrictions on the use of CCA had been imposed, either voluntarily or through regulations.

More studies have been conducted since the review published by Read (2003). The various studies reported in the scientific literature applied different methods for quantification of exposure to arsenic at playgrounds and reviews have expressed opinions of either overestimation or underestimation of exposure. In most cases it was not possible to compare the findings of the various studies directly, because different methodologies and exposure factors were applied to estimate arsenic exposure and health risks.

Following review and critical assessment of the scientific literature that had been published on the matter at the time, Van Niekerk and Fourie (2014) concluded that the cancer risks due to exposure to arsenic at playgrounds could be expected to be lower than the risks estimated for background exposure to arsenic in food and water, and it was reasonable to estimate these risks in the range between 1.0E-06 and 1.0E-04 (between one in a million and one in ten thousand). This risk range is acceptable according to the US Environmental Protection Agency (USEPA) criteria.

In commenting on the Kwon et al. (2004) study, Kissel (2005) remarked that biomonitoring based on urine samples from children who do and do not play on CCA-treated structures would remove uncertainties about arsenic ingestion rates at playgrounds. The pilot study by Shalat et al. (2006) and the more recent study by Lew et al. (2010) convincingly provided this clarification and showed that arsenic levels in urine of children at playgrounds are due primarily to background ingestion of food and water. The studies confirmed that there was no statistically proven difference in arsenic exposure of children who play at playgrounds with CCA-treated wood structures and those that do not have CCA-treated wood structures. Lew et al. (2010) also did not find any differences in the arsenic content of saliva samples between the two groups of children, which support the conclusion that the intake of arsenic is not significantly different between the two groups.

The studies on biological monitoring supported the results of the Kwon et al. (2004) study and the reviews of various studies by Barraj et al. (2009). A coherent set of studies thus indicated insignificant cancer risks associated with exposure to arsenic at CCA playgrounds.

3.2 Supplementary information

A study conducted by Cocker et al. (2006) in the UK sought to gather exposure data based on urinary arsenic and chromium from an exhaustive sample[1] of companies and workers using CCA wood preservatives. Letters were sent to the 440 volunteers, identified by their managers, giving them information about the study and asking for their help. Of these volunteers, 271 workers agreed to participate (63 per cent). Urine samples were received from 217 volunteers in the first round (78 per cent of those agreeing to participate or 49 per cent of workers known to be potentially exposed to CCA). Urinary inorganic arsenic and chromium were determined in workers' samples from four 6-monthly rounds. As the study progressed the number of samples in each round reduced due to normal participant attrition, with 164, 124 and 93 in rounds 2, 3 and 4, respectively.

Volunteers from different companies spread across the UK who had sent in samples for the first two collection rounds were selected to donate 3 urine samples a week for 3 weeks. Samples were received from 19 workers in Scotland, Wales, Northern Ireland and over 12 counties in England. Eleven of these workers sent in a full set of 3 x 3 and a further 6 sent in over 6 samples each. As controls, 241 individuals not occupationally exposed to arsenic and chromium were selected.

[1] Aiming to include all persons possibly exposed

Although the levels of urinary arsenic and chromium in statistical analyses were higher in occupationally exposed workers compared with controls, the levels found in the study were generally within the biological monitoring guidance values (BMGVs) stipulated by the American Conference of Governmental Industrial Hygienists (ACGIH 2004) and German MAK Commission (DFG 2004).

Note that studies that conducted biological monitoring in assessing exposure to CCA-treated wood focused on arsenic, as chromium is fixed in the trivalent state [Cr (III)] in the wood. Cr (III) compounds are not carcinogenic by inhalation, ingestion or dermal contact.

Bühl et al. (2017) determined urinary arsenic in 212 urine samples of 73 woodworkers from six CCA impregnation plants in Uruguay over the period 2014 to 2016. The analyses included inorganic arsenic ("iAs"), monomethylarsonic acid ("MMA"), and dimethylarsinic acid ("DMA"). It had been established that determination of iAs, MMA, and DMA in urine is the method of choice for monitoring of workers exposed to inorganic arsenic (Lauwerys and Hoet 2001). These analyses are less influenced by organo-arsenicals from dietary marine origin.

In one of these plants evaluated by Bühl et al. (2017), 35 workers were interviewed to record individual work-task data, lifestyles, and dietary habits, which may have contributed to their overall exposure to arsenic. Responses were statistically evaluated. These questionnaire data are not important for the purposes of this INFOTOX evaluation, but the results of biological monitoring are of great value in the assessment of health risks due to exposure to CCA in the timber industry.

Out of the 212 urine samples from 73 woodworkers, 96 per cent showed lower levels of urinary arsenic than the adopted guideline concentration of 35 µg/litre of the American Conference of Governmental Industrial Hygienists ("ACGIH"). Only for 9 samples (4 per cent of the total of 212 samples), urinary arsenic values were higher than the ACGIH guideline. After a period of approximately 15 days of workplace removal, the workers re-established safe urinary arsenic values.

Results of the study of Bühl et al. (2017) were consistent with the results published by Cocker et al. (2006), although the latter was a much larger study.

It is important to note that removal of a worker from the work activity in the case of high exposure to arsenic, as indicated by biological monitoring, is an effective and acceptable risk management intervention widely applied in workplaces with exposures to hazardous chemical agents. In such work places, occupational health risk management coupled with occupational medical surveillance are mandated by law in any case, as explained in Section 4. This has to be viewed in the context that exposure to arsenic in wood treatment facilities is not a case of exposure to high acutely-toxic levels, but rather a case of chronic occupational exposures at relatively low concentrations.

The studies reviewed in this section confirm that health risks in the timber industry where CCA is made and used as a wood preservative can be managed effectively where appropriate protective measures are in place.

4 Regulatory context

The overarching obligation of employers in South Africa is to provide and maintain, as far as is reasonably practicable, a working environment that is safe and without risk to employee health (section 8 of the Occupational Health and Safety Act, 85 of 1993 ("OHASA")). The yardstick of *"as far as is reasonably practicable*" is the requirement for the provision and maintenance of systems of work, plant and machinery that are safe and without health risks to health (section 8(2)(a));

eliminating or mitigating health and safety hazards (section 8(2)(b)) and establishing precautionary measures regarding any substance which is produced, processed, used, handled, stored or transported (section 8(2)(d)).

More specifically, occupational exposure to hazardous substances is controlled in South Africa under the Regulations for Hazardous Chemical Agents, 2021, as governed by the Occupational Health and Safety Act no 85 of 1993, *Government Gazette* No 44348 of 29 March 2021 (“HCA Regulations”). The Regulations apply to an employer or self-employed person who carries out tasks at a workplace, which may expose any person to the intake of a hazardous chemical substance. The Regulations apply to the chemical production of CCA and to the timber treatment process.

Note that none of the chemical constituents of CCA are prohibited in terms of the Regulations. Prohibited chemical agents are listed in Table 1, Annexure 2 to the Regulations. Instead, the constituents of CCA are listed in Tables 2, 3 and 4 of the Regulations, where they are assigned occupational exposure limits.

Each worker has to undergo a pre-employment medical designed to cover health symptoms relating to the hazardous chemical agents to which a worker may be exposed. Follow-up scheduled medicals may have to be performed, as determined by the appointed Occupational Medicine Practitioner (“OMP”). Medical examinations may be performed by an Occupational Health Practitioner (“OHP”).

An exposure assessment (also referred to as an occupational risk assessment) has to be performed by an Approved Inspection Authority (“AIA”) in accordance with the requirements of the Department of Employment and Labour under the Regulations. If an assessment indicates that an employee may be exposed, the employer is expected to ensure that adequate protection of the employee is provided, and that monitoring is carried out in accordance with the provisions of the Regulations regarding air monitoring, biological monitoring and medical surveillance.

External exposures may be assessed by sampling and analysing workplace air, and measured values are compared to occupational exposure limits (“OELs”), listed in the Regulations. Exceedance of OELs would require intervention to reduce exposures, or appropriate personal protective equipment may have to be made available to employees. Physical hazards such as temperature and noise, where relevant, also have to be monitored.

Biological monitoring is applied to measure the internal (absorbed) dose of a hazardous chemical agent following exposure (Lauwerys and Hoet 2001). When sampling urine for biological monitoring, analysis is usually performed on “spot” specimens, because routine collection of urine samples from workers throughout a work period is not practical. It is normally recommended to correct analytical results for the extent of dilution of the urine, which differs from person to person, depending on liquid intake or work activity. Since creatinine excretion depends to some extent on urinary flow, it is common practice to apply the creatinine concentration in urine to adjust the measured concentration of an analyte in mg/litre to mg/g creatinine.

In the case of exposure to arsenic, it has been established that determination of iAs, MMA, and DMA in urine is the method of choice for monitoring of workers exposed to inorganic arsenic, because these analytes are less influenced by organoarsenicals from dietary marine origin. A single meal of certain fish species or crustaceans may cause arsenic concentrations in urine of more than 1 000 µg/litre (Lauwerys and Hoet 2001).

For each process, for example, CCA production or timber treatment, an occupational health risk management plan is compiled with the assistance of an AIA and OMP. The plan spells out detail of exposure monitoring and health risk management, and requirements and procedures for medical surveillance.

Since South Africa has adopted the GHS, all hazardous substances have to be classified according to the GHS, and safety data sheets (SDSs) prepared to assist in managing exposure to hazardous substances and potential occupational risks.

Pollution of the environment by hazardous chemicals and human exposure to that pollution is regulated by the National Water Act, 36 of 1998 (“NWA”); National Environmental Management Act, 107 of 1998 (“NEMA”) and the National Environmental Management: Waste Act, 59 of 2008 (“NEM:WA”). These laws govern the incorrect *application* of CCA to timber where, for example it is applied to timber without proper controls and spills (in large quantities in a significant spill or in small quantities over a long period of poor operational practices).

The NWA governs the pollution of water; it criminalises an intentional or negligent act or omission which pollutes or is likely to pollute or detrimentally affect a water resource (section 151(1)(i)) and (j)). It also requires landowners and land users to take reasonable measures to prevent pollution of a water resource from occurring, continuing or recurring (section 19(1)). This is referred to as the “duty of care”. It also gives competent authorities powers to direct landowners and users to take measures to prevent pollution from occurring, continuing or recurring (section 19(3)) and to take those measures and recover the costs of implementing them from anyone who fails to comply with the directive adequately or at all (section 19(5)). Standards are also set for under regulations for water quality for different uses, such as drinking water.

As in the case of the NWA, NEMA imposes a duty of care on landowners and users to prevent pollution of the environment from occurring, continuing or recurring. Directive and cost recovery powers are also conferred on competent authorities under NEMA. These provisions, collectively, require the manufacturer of a substance that may cause pollution of the environment to take reasonable measures to prevent it from doing so.

NEM:WA regulates contaminated land. It imposes notification and investigation obligations where land is contaminated. Regulations made under NEM:WA impose soil screening threshold values for the remediation of contaminated soil on land intended for different kinds uses.

The extensive pieces of legislation presented above provide a framework for safe management of chemicals in production facilities, and throughout use of chemicals in the value chain. This also applies to CCA that is used in timber preservation.

5 Chemical process description

CCA is a water-based preservative containing chromium, copper, and arsenic, manufactured by the three producers in South Africa (see Section on Applicability in the introductory pages of this report). Some of companies are also market players within the African continent. The products and services are supplied to reputable companies supplying treated timber to the agricultural, building and construction, electrical and communications industries.”

Figure 5.1: Raw materials, from left: chromic acid, copper oxide and arsenic acid.

The raw materials are mixed in a reactor at a controlled temperature and in a particular sequence, managed by plant automation. Steam generation is controlled and any off-gas is extracted and removed by carbon filters. CCA is manufactured in batches in a process that is programmed over approximately 8 hours. The production reactors and packaging line are shown in Figure 5.2.

Figure 5.2: Photograph of the production reactors and the packaging line.

The finished product is pumped into bulk storage vessels, from where it is delivered to clients in bulk, or in kegs. These steps are illustrated in Figure 5.3.

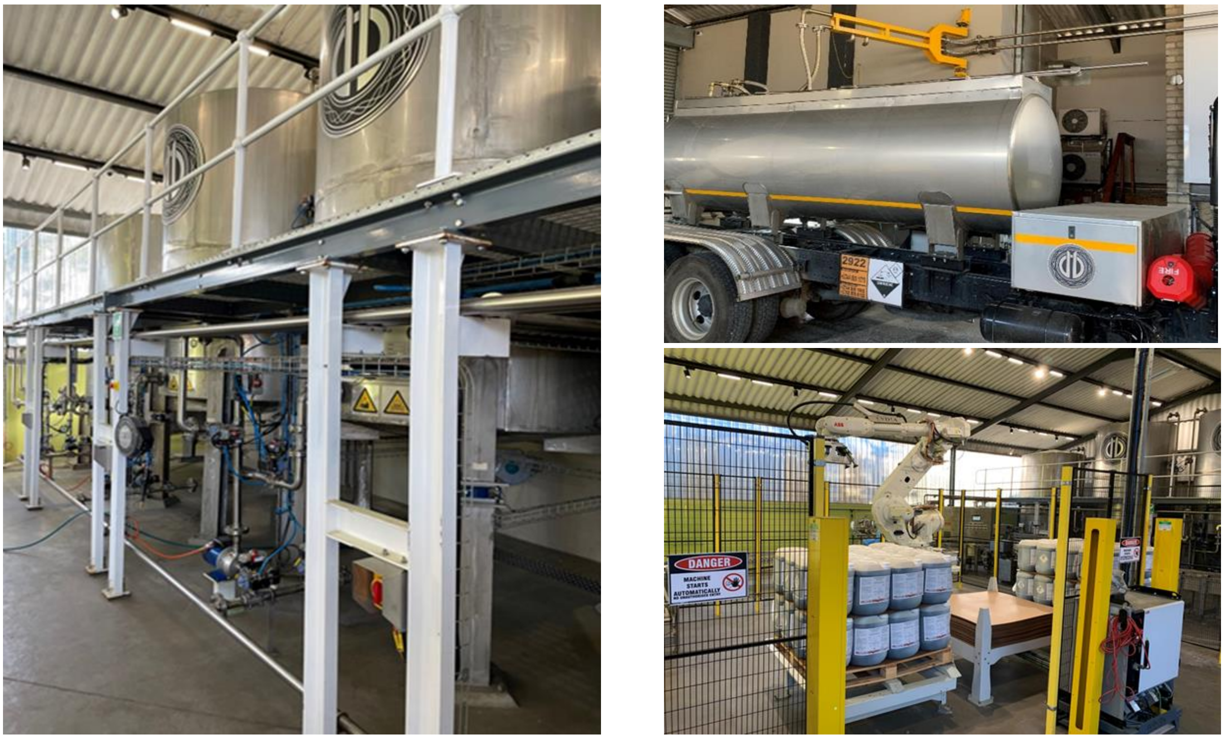


Figure 5.3: Bulk storage of CCA and delivery in bulk or kegs.

The companies have formal occupational health risk management plans that outlines occupational hazards and risks, exposure monitoring, and medical surveillance, in accordance with the Regulations outlined in Section 4 above. They also have the safety data sheet ("SDS") and the product label for their respective CCA products in place, compiled in accordance with the guideline on the implementation of the GHS, issued by the Department in March 2022 (DALRRD. 2022). The SDSs and product labels serve to ensure that management of a CCA product in all its applications will be safe and in accordance with health and environmental legislation, as described in Section 4.

6 Timber-treatment facilities

6.1 Methodology

Figure 6.1.1 illustrates a typical timber treatment facility, operated in South Africa.

The timber is placed in a vessel and impregnated by a preservative under vacuum and under pressure in a closed system in different steps. This is performed in accordance with a range of South African National Standards and European code of practice, as outlined in Sections 6.2 and 6.3.

Figure 6.1.1: Timber treatment plant showing the treatment solution tanks and the closed, blue impregnation vessel in the photograph on the right.

6.2 Operating process of a Timber treatment facility

CCA Timber Preservation Treatment Plants are required by law to be registered with Government to do so. This control ensures that the preservative is only available to registered industrial timber treatment plants. Information in this section was provided by members of SAWPA in the CCA industry.

- Timber is processed for preservation by a stringent grading process. Thereafter, the timber is introduced into the industrial timber preservation plant for treatment with the preservative.
- The preservative is delivered to the processing plant in 45 kg drums or in bulk tanker – no manual handling of the preservative takes place.
- The concentrate preservative is stored in bulk storage tanks, the working solution in working tanks that are located within a bunded area, the latter of which can hold a minimum of 110 per cent of the total tank capacity.
- Transfer of the liquid during the process of solution preparation occurs through a series of valves and pumps and does not necessitate any human intervention.
- The timber is railed into the treatment plant autoclave where a series of vacuum and pressure cycles is applied to hydraulicly force the CCA wood preservative into the timber and withdraw any superfluous preservative from the surface of the timber.
- Thereafter, the redox processes begin, which results in the preservative being chemically fixed in the timber.
- The treated timber is only released for sale once the fixation process is complete, where upon it is safe to handle and use.

6.3 South African National Standards

Timber treatment plants are used internationally for impregnating timber with various types of preservatives and/or fire retardants. Various standards have been published by the South African Bureau of Standards, some of which are listed below.

- South African National Standard SANS 673:2017 Ed 3.04 provides guidance on requirements for mixtures of copper-chromium-arsenic compounds for timber preservation.

- South African National Standard SANS 753:2018 Edition 5 provides guidance on requirements for pine poles, cross-arms and spacers for power distribution, telephone systems and street lighting.

- SANS 1288:2020 Ed 4 on preservative-treated timber is supported by a narrative that outlines the importance of treatment of timber in the economy of South Africa. The document states that "(*A)ll timber, when exposed under certain conditions, is subject to attack by wood-destroying organisms, the more common destructive organisms being fungi, wood-destroying insects, marine borers and bacteria".*

  According to South African National Standard SANS 1288, economic losses due to adverse impacts on wood in the absence of treatment with a preservative are considerable, although difficult to estimate. SANS 1288 also points out that some of the treatment formulations are ineffective for the given hazard conditions.

  The purpose of this standard is to set nationally accepted levels of preservative treatment of timber for a classified range of hazard conditions, and thus to promote and extend the use of timber and to conserve raw material."

- South African National Standard SANS 10005:2020 Ed 9 sets guidance on the preservative treatment of timber. The purpose of this standard is "*to give guidance on required timber treatment processes and preservatives and to establish a common basis of methods and criteria for the timber industry".* The standard also gives recommendations to the handling and safety of preservative treated timber.

- South African National Standard SANS 10255: 2009 Ed 3 is a comprehensive guidance document for safe management of timber treatment facilities, including reference to the use of CCA in timber treatment. SANS 10255 lists a range of other SANS documents as normative references. Note that SANS 10255 is currently under revision to align the standard with latest legislation and best practices.

In addition to the SANS guidance standards, occupational exposure to hazardous substances is controlled in South Africa under the HCA Regulations as outlined in Section 4 above. All wood treatment facilities have to comply with the Regulations and implement occupational health risk management plans.

6.4 European code of practice

It is valuable to illustrate that South Africa's standards are aligned with best practice applied by industry bodies regulating the operation of state-of-the-art wood treatment facilities by industry organisations in the European Union ("EU").

- The European Institute for Wood Preservation ("WEI-IEO") is the European industry trade association representing the pressure treated wood industry. It argues for the benefits of treated wood whilst representing the wood preservation industries within the EU. The activities of the WEI-IEO are based around wood preservatives, environmental and technical issues and the marketing of finished wood products.

- European Wood Preservative Manufacturers Group ("EWPM") aims to promote the correct use of wood preservatives including production, transportation, utilisation and disposal. It acts as an official representative of the industry when approaching authorities, institutions and any other competent body on a European or international level.

These two organisations developed and published a European Code of Practice for wood treatment facilities (WEI-IEO and EWPM 2021). The purpose of this Code of Practice is to provide generic guidance on environmental, safety and health aspects relevant to all companies in the EU engaged in the activity of industrial wood preservation. Such guidance is also intended to be useful to those regulatory authorities responsible for regulating the wood preservation industry, for third party inspectors and certification authorities.

7 CCA use restrictions under REACH

7.1 Relevance of REACH

South Africa has adopted the GHS, which provides guidelines and criteria for hazard classifications in the categories of physical hazards, hazards to human health, and hazards to aquatic ecosystems. Hazard classifications of chemicals in South Africa should thus be aligned with the scientific principles of classification and health risk assessment followed in the EU.

In this regard it is of value to consider the assessment procedures followed in the EU through the Registration, Evaluation, Authorisation and Restriction of Chemicals ("REACH"). The REACH Regulation aims to enhance the protection of human health and the environment through improved and earlier identification of the intrinsic hazardous properties of chemical substances.

REACH places the responsibility on industry to identify and manage the risks from hazardous chemicals and to provide safety information on the chemicals. Manufacturers and importers are expected to acquire information on the hazardous properties of chemical substances that they deal with, thus permitting safe handling. The information on hazards has to be registered in a central database in the European Chemicals Agency ("ECHA") in Helsinki. ECHA is an agency of the EU that manages the technical and administrative aspects of the implementation of REACH.

The Regulation also requires the progressive substitution of the most dangerous chemicals (referred to as "*substances of very high concern*") when suitable alternatives have been identified.

Karamertzanis et al. (2019) specifically evaluated the impact on classifications of carcinogenicity, mutagenicity, reproductive and specific target organ toxicity after repeated exposure in the first ten years of implementation of the REACH regulation. The authors highlighted that classification for carcinogenicity, mutagenicity, reproductive toxicity and specific target organ toxicity (repeated exposure) ("STOT RE") triggers several obligations for manufacturers, importers and professional users.

Karamertzanis et al. (2019) then stated:

"In addition to such consequences under other legislations (sic)*, registrants are required to carry out exposure assessment and risk characterisation for substances that are classified and, hence, classification under REACH is a trigger for risk assessment for human health*."

Note that under REACH there is no total prohibition on the use of arsenic compounds. The approach followed in REACH is based on exposure assessment and risk characterisation in the registration of chemicals, as highlighted by Karamertzanis et al. (2019).

Annex XVII to REACH (ECHA online) lists restrictions on the manufacture, placing on the market and use of certain dangerous substances, mixtures and articles. Entry 19 lists conditions of restriction for arsenic compounds. It is important to note that restrictions apply where there is a risk of repeated skin contact, or any application in which the treated wood may come into contact with intermediate or finished products that are intended for human and/or animal consumption.

Entry 19 notes that substances and mixtures for the preservation of wood "*may only be used in industrial installations using vacuum or pressure to impregnate wood if they are solutions of inorganic compounds of the copper, chromium, arsenic (CCA) type C and if they are authorised in accordance with Article 5(1) of Directive 98/8/EC. Wood so treated shall not be placed on the market before fixation of the preservative is completed*".

The matter of fixation is appropriately addressed in the commercial CCA wood treatment process and forms part of standard quality assurance. This is discussed in detail in Section 8.2.

Instructions aligned with Entry 19 are regularly expressed in SDSs and on product labels provided by South African CCA manufacturers. One example is: "*For industrial use only*"; "*Waterborne wood preservative … for application, after appropriate dilution, by vacuum/pressure impregnation*"; "*Vacuum pressure treatment impregnation plants shall be designed and operated in accordance with relevant SANS or equivalent codes of practice to minimise exposure of people to the product and treatment solution and treated wood must not be used or dispatched until at least 24 hours after treatment"*.

Entry 19 then lists a number of industrial applications for which CCA may be used:

- As structural timber in public and agricultural buildings, office buildings, and industrial premises,
- In bridges and bridgework,
- As construction timber in freshwater areas and brackish waters, for example jetties and bridges,
- As noise barriers,
- In avalanche control,
- In highway safety fencing and barriers,
- As debarked round conifer livestock fence posts,
- In earth retaining structures,
- As electric power transmission and telecommunications poles,
- As underground railway sleepers.

It cannot be assumed that this list is exhaustive, and by applying professional judgement, there may be other applications where there is no potential for repeated skin contact, for which CCA-treated timber should not be restricted under REACH. INFOTOX elaborates on the issue of skin contact with CCA-treated wood in Section 7.2.1 below.

7.2 Restrictions under REACH placed in context

7.2.1 Residential use of CCA-treated wood

REACH does not have legal standing in South Africa (except possibly under common law, where implementing its requirements are arguably the taking of reasonable measures to prevent harm). Not all restrictions under REACH in the EU may be scientifically defensible. For example, according to Entry 19, CCA-treated wood shall not be used in "*residential or domestic constructions, whatever the purpose*".

The premise on which use of CCA-treated wood in all residential or domestic structures is restricted is based on concerns about arsenic being dislodged from treated wood through frequent hand contact. These concerns were raised originally because of CCA-treated wood in children's playsets. As was asserted by Van Niekerk and Fourie (2014), the risk of developing cancer from childhood contact with arsenic in children's playsets was largely inconclusive. Generally, where the health of children may be at stake, especially where there is a potential risk of cancer, the notion is that it is "better to be safe than sorry". The voluntary restriction on the use of CCA-treated wood in children's playsets at the time was thus based on invoking the precautionary principle.

It is on this premise that CCA-treated wood in residential and domestic structures, in general, is restricted under REACH. The decision was also driven by the extensive use of wood in residential constructions in Europe. Wood is strongly promoted as a sustainable construction material (Interreg Europe 2021). It is also important to refer to the Build-in-Wood initiative. Build-in-Wood was a European funded Horizon 2020 project, the objective of which has been to significantly increase the proportion of timber construction in buildings (Build-in-Wood 2020). Horizon 2020 was the EU's research and innovation funding programme from 2014-2020.

It is not uncommon in residential construction in Europe (and in countries such as the United States of America and Canada) for walls and floors to be made from wood. In some cases, there is a single-layer outside brick wall and indoor walls are all constructed from wood. Clearly, there is a significant potential for repeated skin contact with wood under such conditions, and if the wood had been treated with CCA, the concern about contact with arsenic would arise, irrespective of scientific certainty about actual exposures and health risks. Regulators typically apply the precautionary principle in such cases, although this may not be warranted from a purely scientific perspective, as was pointed out by Van Niekerk and Fourie (2014).

It is important to note that none of these regulatory decisions in the EU on the use of CCA-treated wood apply to CCA-treated wood already in use (Read 2003). In itself this suggests that the steps are precautionary and that the estimated cancer risks due to exposure to arsenic in existing structures are low, if not insignificant. If health risks associated with CCA-treated wood already in use were certain and measurable, there would not have been a defensible position to leave existing CCA-treated wood structures in place.

Arguments against using CCA-treated wood in residential and domestic constructions in Europe, irrespective of the assumptions on which such arguments are based, cannot be applied in South Africa. Residential buildings in South Africa are predominantly built using brick and mortar. Wood used indoors for doors, windows, cupboards, etc, is usually natural hardwood that is not impregnated with CCA. Indoor wall panelling is normally plywood, which is also not CCA-treated. CCA-treated wood is also not used in flooring. The only frequent application for CCA-treated timber in residential construction in South Africa is for roof trusses and rafters.

The general restriction in the EU on using CCA-treated wood in "*residential or domestic constructions, whatever the purpose*", is not recommended for application in South Africa. The inference about health risks due to frequent hand contact with CCA-treated wood is not based on scientific studies where risks were undisputedly demonstrated, but the precautionary principle was invoked. Van Niekerk and Fourie (2014) asserted that at the time of the voluntary agreement to restrict certain uses of CCA-treated wood in the USA, reached in February 2002 between the registrants of CCA and USEPA, there were only a few scientific studies about health risks of children at playsets, and the studies were not conclusive about the level of risks. It was thus appropriate to invoke the precautionary principle at that time. However, later studies based on arsenic levels in urine of children at playgrounds concluded that exposures to arsenic were due primarily to background ingestion of food and water (Shalat et al. 2006; Lew et al. 2010). The studies confirmed that there was no statistically proven difference in arsenic exposure of children between playgrounds with CCA-treated wood structures and those that do not have CCA-treated wood structures. The studies on biological monitoring supported the results of the Kwon et al. (2004) and Barraj et al. (2009) studies. An overarching restriction on using CCA-treated wood in residential construction based on the precautionary principle is thus not warranted, considering the outcomes of the studies referred to above. This statement should also be read in context with scientific explanations in other sections in this INFOTOX report.

7.2.2 The matter of decks in perspective

The CCA-treated decks referred to in previous studies (Van Niekerk and Fourie 2014) were all part of children's playsets (Hemond and Solo-Gabriele 2004; USEPA 2005; Barraj et al. 2009; Chen et al. 2008; Stilwell and Gorny 1997; Zartarian et al. 2006). The figure below illustrates a typical deck as part of a playset.

Reference: naturalplaygroundsstore.com

Activity patterns at children's playsets would be markedly different from human activity patterns at domestic outdoor decking and walkways. Van Niekerk and Fourie (2014) concluded that there was a coherent set of studies that indicated insignificant cancer risks associated with exposure to arsenic at CCA playgrounds, and the voluntary restriction on use of CCA-treated wood at playgrounds was based on invoking the precautionary principle.

Exposure of children to dislodged arsenic from CCA-treated wood playsets was not based on dermal absorption, but by considering the hand-to-mouth activities of small children, and potential exposure through ingestion (Kwon et al. 2004; Gradient Corporation 2001).

Figure 7.2.2.1: Example of a children's playset showing the integrated deck.

There are no convincing reasons to prohibit use of CCA-treated timber for outdoor domestic decks and walkways based on demonstrated health risks to members of the public. Exposure through significant ingestion of any potential dislodged arsenic is remote, and dermal uptake (for example when walking barefoot on a deck or walkway) would be insignificant. Wester et al. (2004) conclusively showed that arsenic was poorly absorbed from CCA-treated wood residues on dermal contact, not resulting in urinary arsenic excretion in urine above background levels. More information of this study is presented in Section 9.2 of this report.

8 Preparations and bio-accessibility in context

8.1 The example of stainless steel

The issue of bio-accessibility was first raised by the alloy industry, where stainless steel classified as hazardous according to the GHS, because of its nickel content. Cancers of the lung and nasal sinus have developed in workers breathing dust containing high levels of nickel compounds while working in nickel refineries or nickel processing plants. Inhalation is thus the route of exposure of concern for nickel compounds.

Stainless steel is formed when the raw materials of nickel, iron ore, chromium, silicon, molybdenum, and others, are melted together in a high-temperature electric arc furnace. Stainless steel contains a variety of chemical elements that, when fused together, form an alloy. Properties of the final alloy are designed by varying the amounts of the various elements. There are many different types of stainless steel which are used in a multitude of applications, including industrial food processing and household utensils.

Based on the GHS classification and labelling criteria for mixtures, many stainless steels should be classified as specific target organ toxicants and/or category 2 carcinogens because of their total nickel content. However, available stainless-steel-specific data provide convincing evidence that such classification is scientifically incorrect (Santonen et al. 2010).

The concept of bio-accessibility is a critical factor for understanding chemical hazards of a material. Bio-accessibility describes the fraction of an element in a material that can become available for absorption into the human circulatory system. Bio-availability, on the other hand, represents the fraction of an element that is actually absorbed into the circulatory system. The bio-accessible fraction of an element is determined through in-vitro extractions in biological fluids, namely, alveolar (lung) fluid, gastric fluid, intestine fluid, and sweat, representing bio-accessibility through inhalation, ingestion and dermal contact.

Synthetic lung fluid is a laboratory-prepared liquid used to replicate physiological conditions in the lung, for studying dissolution mechanisms of substances when inhaled. In vitro extraction tests showed that nickel released from stainless steel in synthetic lung fluid was substantially lower than from nickel metal, due to the chromium (III) oxide enrichment at the surface of stainless steel.

A study on stainless steel inhalation exposure showed low inhalation toxicity when compared to nickel powder. Therefore, no classification for target organ toxicity in repeated exposures to stainless steel was proposed by Santonen et al. (2010). Low bio-accessibility of metallic constituents and available toxicological data do not support classification for mutagenicity or carcinogenicity either.

The conclusion from the stainless-steel matter is that it cannot be regarded as a mixture of chemicals, but rather as a “preparation” of which its inherent hazards are not reflected by the hazards of the individual chemicals, but the preparation as a whole has to be assessed for hazardous properties. From the description of its manufacturing process, it is easy to understand that stainless steel is a preparation, and not a mixture of chemicals as is normally considered in GHS classifications. Other examples of preparations include alloys other than stainless steel, soil, natural geological materials, and metallurgical slag from mineral processing facilities. It is shown in Section 8.2 below that CCA-treated wood should also be considered a preparation, not a mixture of the chemical constituents of CCA.

8.2 CCA-treated wood as a preparation

SANS 5993:2018 Ed 2 provides detail on the use of diphenyl carbazide as an indicator for the presence of hexavalent chromium ions [Cr (VI)] in timber; which is also used as an indicator of fixation. The use of an indicator to determine fixation is mandated by both SANS 10005:2020 Ed 9 and SANS 5993:2018 Ed 2, and is also a condition in Entry 19 in Annex XVII to REACH, as described in Section 7.

The process of fixation is the slow reduction or conversion of Cr (VI) in timber to trivalent chromium ions [Cr (III)] as a result of reactions with cellulose and lignin. Trivalent chromium ions form insoluble complexes which allow impregnated CCA solution to be even more resistant to leaching than arsenic. More information about leaching characteristics of arsenic and chromium from CCA-treated wood is presented in Section 9.2 below.

Timber that is not allowed to fixate completely will contain residual amounts of Cr (VI). This means an increase in the mobility of the CCA in wood and results in a greater risk of the preservative leaching out of the timber.

Immediately after impregnation of CCA solution into timber, the following two stages occur in the fixation process:

- Stage 1 – Cr (VI) is adsorbed onto cellulose and lignin in the wood. Some Cu (II) is also adsorbed onto the cellulose. Some Cu (II) and As (V) also bound to the adsorbed Cr (VI). This process is complete within minutes.
- Stage 2 – Cr (VI) is slowly reduced to Cr (III) within the wood. This process may take hours to days to complete and is temperature dependent. During this process Cu (II) and As (V) also bonds to the Cr (VI) and Cr (III) ions. This stage is also accompanied by an increase in pH, as a result of the reduction reaction.

The following insoluble compounds may form:

$CrAsO_4$
$Cu(OH)CuAsO_4$
$CuCrO_4$
$Cr_2(OH)_4CrO_4$
$Cr(OH)_3$

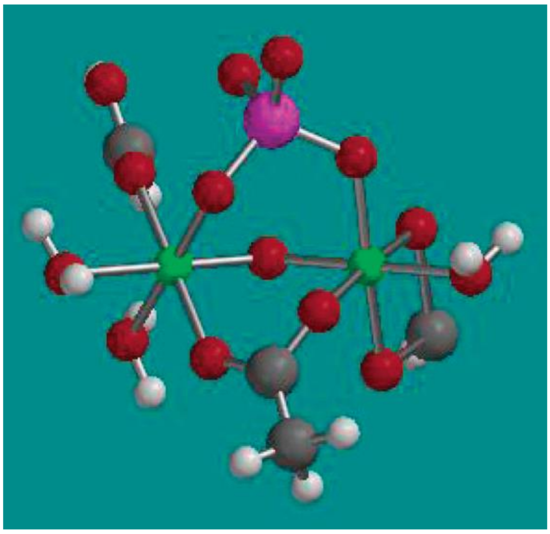
The presence of Cr (VI) ions can be detected by spraying a solution of diphenyl carbazide and serves as an indication that the process of reduction is incomplete.

The purple colour indicates wood not fully fixated, where diphenyl carbazide reacted with Cr (VI). The absence of purple colour indicates fully fixated wood.

Figure 8.2.1. Diphenyl carbazide test for assessing CCA fixation in wood.

CCA in treated wood is thus no longer a mixture of Cr (VI), Cu (II) and As (V), and a GHS classification has to acknowledge bio-accessibility, similar to the example of stainless steel discussed in Section 8.1. Bio-accessibility of arsenic from CCA-treated wood is discussed in more detail in Section 9.2.

Nico et al. (2004) suggested a model of the Cr-As cluster, as illustrated in Figure 8.2.2.



Oxygen atoms are shown in red, chromium atoms in green, carbon in grey, hydrogen in white, and arsenic as a large purple ball.

It is clear that CCA in the treated wood cannot be regarded as a mixture of chemicals, but as a preparation similar in concept to stainless steel, geological rocks, soil, etc. The factor of bio-accessibility of hazardous substances should thus be considered when assessing hazards and potential health risks.

Figure 8.2.2: Model of Cr-As cluster.

9 Bio-accessibility: significance in exposure and risk

9.1 Bio-accessibility of arsenic from soil

Cr (VI) is reduced to Cr (III) in the CCA wood treatment process and since Cr (III) is not carcinogenic and has low systemic toxicity, it is not considered in in terms of health risks in this INFOTOX document. Chromium occurs naturally in the environment and any potential contamination of soil with Cr (III) as a result of CCA-treated wood would be minute and thus would not be of health concern. Similarly, copper concentrations in soil at environmental background levels are not of health concern, and any potential low addition to soil from CCA-treated wood would not be of health concern.

Arsenic contamination of soil is discussed in this section, considering several publications in the scientific literature about arsenic in soil at children's playsets, claimed to have leached from CCA-treated wood into rainwater and subsequently into soil. Scientific references for the publications are presented in this section. Given the small amounts of the constituents of CCA that are leached from treated wood structures over time, and the fact that these constituents bind to soil components, groundwater is not considered to be a source of public exposure from CCA-treated wood (Read 2003). This has also been confirmed in the USA by studies of arsenic in groundwater at construction and demolition ("C&D") debris facilities with wood mono landfills, and Class III solid waste disposal facilities. These facilities do not have containment liners. INFOTOX published a review of the relevant available scientific information on groundwater monitoring at these sites (Van Niekerk 2015). The findings of INFOTOX are best summarised by the study conducted by

Kavanaugh et al. (2005), who concluded that "*there is no evidence that the disposal of CCA-treated wood in unlined landfills is contributing to arsenic levels in groundwater*".

There is no possibility for volatilisation of constituents of CCA from treated timber, since the constituents are converted into a preparation, as explained in Section 8.2 above. Air is thus not regarded as a potential pathway of exposure, except for inhalation of airborne soil particulates.

The soil pathway of exposure to arsenic has been considered in several studies of exposure at playgrounds (Stilwell and Gorny 1997; Ursitti et al. 2004; Hemond and Solo-Gabriele 2004). Generally, soil arsenic concentrations were compared with guideline concentrations for arsenic in soil, which range from less than 0.05 mg/kg to well over 100 mg/kg, depending on the criteria for selecting a guideline (TEAF et al. 2010). This must also be viewed in the context that arsenic in soil in certain regions in South Africa is naturally above 100 mg/kg (SRK 2001). Some of the guidelines simply adopted background soil concentrations as the guideline, with no acknowledgement of the potential for health risks. Comparison of total arsenic in soil against a soil guideline concentration cannot be used as a measure of health risk, because the total concentration of a hazardous substance may not be available for absorption into the human circulatory system. Total arsenic concentrations in soils underneath children's playsets can thus not be related to health risks of children without acknowledging the factor of bio-accessibility (Bari et al. 2021; Saikat et al. 2007; CNTC 2006). Following discussions on preparations and bio-accessibility in Section 8 above, soil in which playsets are anchored is also not representative of a mixture of chemicals as understood under the GHS, but it is more correctly described as a preparation, as has been explained in Section 8 above. The same can be said for arsenic in soils around CCA-treated utility poles.

Exposure to arsenic in soil at playgrounds was shown to be lower than exposure from playsets and decks and the addition from this pathway to non-cancer and cancer risks would not affect the overall interpretation of cancer risk (Gradient Corporation 2001; Chen et al. 2008; Kwon et al. 2004; Zartarian et al. 2006). Gradient Corporation (2001) calculated combined inhalation, dermal and oral exposure to arsenic-contaminated soil particulates in residential and playground settings. Based on conservative assumptions and parameters to quantify exposures, the results of the health risk assessments indicated that use of CCA-treated wood in both a residential and playground setting would not pose a significant health risk to children or adults. These studies indicated that exposure due to arsenic in soil is not regarded as constituting health risks at children's playgrounds where CCA-treated wood playsets were installed.

Pouschat and Zagury (2006) conducted an investigation of in vitro gastrointestinal bio-accessibility of arsenic in soils collected near CCA-treated utility poles. Arsenic bio-accessibility in gastric and intestinal solutions was determined on 12 surface soil samples collected immediately adjacent to the poles. The mean arsenic gastrointestinal bio-accessibility was 40.7 ± 14.9 per cent for the 12 field-collected soils. Based on typical exposure parameters of children, the mean daily intake of arsenic from the contaminated soil was shown to be negligible compared to the daily total arsenic intake from dietary exposure (water and soil) (Pouschat and Zagury 2006). Arsenic intake was based on the mean daily intake of inorganic arsenic from food for children aged 1-to-6 years old, estimated by Yost et al. (2004). The mean arsenic intake is 0.18 µg/kg-day, with a range of 0.09 to 0.35 µg/kg-day for the 10^{th} and 95^{th} percentiles, respectively. The intake is quantified as µg As per mean body weight per day. The value of 0.09 µg/kg-day for the 10^{th} percentile means that 10 percent of the test population would have arsenic intakes equal to or less than 0.09 µg/kg-day, and the value of 0.35 µg/kg-day for the 95^{th} percentile means that 95 per cent of the test population would have inorganic arsenic intakes from food equal to or less than 0.35 µg/kg-day. Exposure through water was based on a mean intake of 1 litre of water per day, with inorganic arsenic content of 5 µg/litre, which is half of USEPA's drinking water standard.

The information presented in this section confirms that exposure to inorganic arsenic in soil at children's playgrounds with CCA-treated wood playsets are insignificant, both in terms of cancer and non-cancer health endpoints. The calculated health risks are lower than estimates of risks associated with background dietary exposures.

9.2 Bio-accessibility of arsenic from CCA-treated wood

The factor of bio-accessibility from CCA-treated wood has been well illustrated in a study conducted by Nico et al. (2006). The study addressed the leaching characteristics of brush-removed and hand-removed residues from CCA-treated boards. In addition, the surface of a weathered CCA-treated board (from an old deck) was removed to a depth of approximately 0.3 cm as small wood chunks. These residues and wood chunks were extracted into biologically relevant solvents, namely human sweat and simulated gastric fluid.

The residues consisted primarily (96 percent) of wood particles containing As and Cr bound together in an As-Cr complex. Nico et al. (2006) found that approximately 12 per cent of the arsenic within the residues was bio-accessible under the relatively mild conditions of leaching in human sweat, and an additional 9 per cent was bio-accessible under the harsher simulated gastric fluid conditions. The remaining approximately 80 per cent of the arsenic and 90 per cent of the chromium appeared to be immobile, even under the harsher conditions, remaining bound within wood particles the As-Cr complex described above. It was reasoned that the unstable fraction of arsenic was likely composed of either weakly adsorbed arsenate ions or $CrAsO_4$ particles that were present in small amounts in the residue. Whatever the details of release mechanisms may be, the important inference is that only approximately 20 per cent of the arsenic and 10 percent of the chromium are bio-accessible. As indicated in Section 9.1, chromium leached from treated wood as Cr (III) is not of health concern, and the focus is thus on arsenic.

In a study by Wester et al. (2004), urinary excretion of arsenic above background levels could be measured following dermal application of soluble arsenic. The most direct way of measuring exposure to inorganic arsenic is through biomonitoring of arsenic in urine (Lauwerys and Hoet 2001). As summarised by CDC (online), urinary arsenic levels reflect recent exposures and the concentrations correlate moderately to highly with arsenic intakes from drinking water and dietary sources. Calderon et al. (1999) reported that daily variation in creatinine-corrected urinary arsenic is relatively small when intake is constant. Absorption rates of 0.6-to-4.4 per cent reported by Wester et al. (2004) were consistent with prior research using the more sensitive, radio-labelled technique. The study further showed that arsenic was poorly absorbed from CCA-treated wood residues on dermal contact, not resulting in urinary arsenic excretion above background levels.

10 GHS classification of CCA-treated wood

The composition of CCA and mass percent concentrations of arsenic, chromium and copper in treated wood are presented in Tables 10.1 and 10.2 for Pine and Eucalyptus, respectively. The bio-accessible fractions are also listed, based on Nico et al. (2006) that indicated approximately 20 per cent of arsenic is bio-accessible. For the purpose of the GHS calculations, it was assumed that arsenic, chromium and copper were all bio-accessible at the same level.

According to GHS guidance, there are certain concentrations, applicable to some hazard classes, below which an ingredient ceases to be viewed as a "relevant ingredient" for hazard classification purposes, unless there is sufficient "reason to suspect" that the ingredient is relevant for classification of the mixture as toxic or hazardous, even below the concentration suggested by GHS guidance. Ingredients not relevant to the hazard classification of the mixture (the material) are identified by comparison of ingredient concentrations with the "relevant ingredient" concentrations suggested in the GHS Purple Book (UN 2021). These comparisons are presented in Table 10.3. The concentrations calculated in Tables 10.1 and 10.2 are quite low, and none are higher than 0.1 mass %.

INFOTOX considers the hazard classification data for chemical substances in the Brief Profile and in the Classification and Labelling inventory (C&L inventory) of ECHA as the basis to determine if there is "reason to suspect" that an ingredient is relevant at concentrations below those suggested by GHS guidance. The Brief Profile summarises the non-confidential data on substances available in the ECHA databases (ECHA online). INFOTOX relies on the harmonised classifications, if available, in preference to the classifications presented by various industrial and business parties to the C&L inventory. The reason is that a harmonised classification is legally binding at the European Community (EC) level to ensure adequate risk management of a specific substance throughout the EC. Furthermore, the harmonised classification is determined with input of Member States, manufacturers, importers and downstream users and is determined by a rigorous process of review of scientific data and structured stakeholder input.

The GHS "relevant ingredient" concentrations applicable to the GHS health hazard classes are presented in Table 10.3. The ECHA databases classifications of arsenic, chromium and copper are also provided. The highest bio-accessible concentrations were obtained in treated Pine wood (Table 10.1), namely, 0.09, 0.10 and 0.06 percentage by mass of As (V), Cr (III) and Cu (II), respectively.

Table 10.1: Elemental concentrations in CCA-treated Pine (density 450 000 g/m^3).

Element	CCA in solution (g/kg)	Retention (kg/m^3)	CCA in timber (g/m^3)	Total mass % in wood	Mass % bio-accessible
As	130	16	2 080	0.46	0.09
Cr	145	16	2 320	0.52	0.10
Cu	90	16	1 440	0.32	0.06

Table 10.2: Elemental concentrations in CCA treated Eucalyptus (density 650 000 g/m^3).

Element	CCA in solution (g/kg	Retention (kg/m^3)	CCA in timber (g/m^3)	Total mass % in wood	Mass % bio-accessible
As	130	16	2 080	0.32	0.06
Cr	145	16	2 320	0.36	0.07
Cu	90	16	1 440	0.22	0.04

These concentrations are used conservatively for the evaluation of relevance to hazard classification. It can be seen from the relevant ingredient limits presented in Table 10.3 that the bio-accessible concentrations of all three elements are irrelevant to all hazard classes to which relevance limits are applicable. Nonetheless, any "reason to suspect" that an ingredient is relevant at concentrations below those suggested by GHS guidance is sought by obtaining the ECHA databases health hazard classifications of all three elements, as presented in Table 10.3 and discussed further in this section.

It was necessary to find the hazard classifications of analogues of the elements, because health hazard classifications of single elements cannot be obtained in practice. The elements are complexed in treated wood (see Section 8.2), but a hazard classification for the complex is also not available. Thus, the only viable approach is to use the principal of read-across, by deriving the likely hazard classifications of the elements from the known health hazard classifications of ionic substances containing these elements. The analogues ionic substances presented in Table 10.3 were chosen on the basis of solubility in water, as far as possible, and on the basis of the likely low toxicity of the ionic "partner" in the analogues substance, such as sulfates in the cases of Cr (III) and Cu (II).

Table 10.3: Relevant ingredient limits and ECHA databases health hazard classifications of As (V), Cr (III) and Cu (II).

Hazard class	GHS concentration limit of "relevant ingredient"	ECHA database classification		
		As (V) Arsenic acid analogue	Cr (III) $Cr_2(SO_4)_3$ analogue	Cu (II) $CuSO_4$ analogue
Acute toxicity	≥ 1%	Acute toxicity cat. 3 (ingestion & inhalation) Not classified by dermal route	Not classified by any route	Acute tox. cat. 4 (ingestion) Not classified by dermal or inhalation routes
Skin corrosion/ irritation	≥ 1%	Skin corrosion cat. 1A	Not classified	Skin irritation cat. 2
Eye damage/ irritation	≥ 1%	Serious eye damage Cat. 1	Not classified	Serious eye damage Cat. 1
Skin and respiratory sensitisation	Not proposed	Not classified	Not classified	Not classified
Specific target organ toxicants	≥ 1%	Not classified	Not classified	Not classified
Carcinogen	Not proposed	Carc. Cat. 1A	Not classified	Not classified
Mutagenicity	Not proposed	Not classified	Not classified	Not classified
Reproductive toxicant	Not proposed	Repr. Tox. Cat. 2	Not classified	Not classified
Aspiration hazards	≥ 1%	Not classified	Not classified	Not classified

<u>Evaluation of acute toxicity</u>

The GHS Purple Book (UN 2021) states in *Decision logic 3.1.2 for acute toxicity* that the acute toxicity estimate (ATE) equation may be used to calculate the ATE of a mixture (ATE_{mix}), for comparison with the trigger limit concentrations for classification of the mixture in acute toxicity hazard categories. For the purposes of this evaluation, simultaneous exposure to the elements As (V), Cr (III) and Cu (II) is viewed as exposure to a mixture of these elements, at the bio-accessible concentrations presented in Table 10.2. The evaluation is conducted by the relevant routes of exposure, which are the routes by which an element has been classified as hazardous, as presented in Table 10.3. The additivity equation is presented as follows in the Purple Book *Decision logic 3.1.2*:

Apply the acute toxicity estimate calculation to determine the ATE of the mixture

$$\frac{100}{ATE_{mix}} = \sum_{n} \frac{C_i}{ATE_i}$$

where:
C_i = concentration of ingredient i
n = ingredients and i is running from 1 to n
ATE_i = Acute toxicity estimate of ingredient i

It is stated in the Purple Book Paragraph 3.1.3.6.1 that the following guidelines should be adhered to when the formula is used:

a) *Include ingredients with a known acute toxicity, which fall into any of the GHS acute toxicity hazard categories*
b) *Ignore ingredients that are presumed not acute toxic (e.g., water, sugar)*
c) *Ignore ingredients if the data available are from a limit dose test (at the upper threshold for Category 4 for the appropriated route of exposure as provided in Table 3.1.1) and do not show acute toxicity*

Provision (a) is applicable to As (V) and Cu (II) and provision (c) is applicable to Cr (III), which is not classified with regard to any of the acute hazard classes.

Thus, the ingredients included in the additivity calculation are As (V) by the oral and inhalation routes of exposure and Cu (II) by only the oral route. The other routes are not relevant, because the elements were not classified as acute toxicity hazards by these routes (compare with the hazard classifications in Table 10.3).

According to the Purple Book Table 3.1.2, acute toxicity hazard categories of classified ingredients may be used to derive ATEs of these ingredients. The converted ATEs are presented in Table 10.4. Concentrations and converted acute toxicity estimates (ATEs) of As (V) and Cu (II) may be used in the additivity formula to calculate the acute toxicity estimates of ingestion and inhalation of the mixture of As (V) and Cu (II) bio-accessible from the treated wood. These are also presented in Table 10.4.

The division of the bio-accessible concentration of the element in wood by the converted ATE, that is, C_i/ATE_i, is calculated and presented in Table 10.4. The results of these calculations are summed according to the route of exposure (Table 10.4), for subsequent application in the additivity equation, illustrated in Table 10.4. The maximum bio-accessible concentrations, from treated Pine wood (Table 10.2) are used.

Table 10.4: Converted ATEs of As (V) and Cu (II).

Element and calculation	Ingestion (oral) category	Converted ATE (mg/kg)	Inhalation category	Converted ATE (mg/litre - dusts)
As (V)	Category 3	100	Category 3	0.5
As (V) Ci/ATEi for use in the additivity equation	0.09/100 = 0.0009		0.09/0.5 = 0.18	
Cu (II)	Category 4	500	Not applicable – Cu (II) not classified as acute hazard by the inhalation route (Table 12.3)	
Cu (II) C_i/ATE_i for use in the additivity equation	0.06/500 = 0.00012			
C_{As}/ATE_{As}+ C_{Cu}/ATE_{Cu}	0.0009+0.00012 = 0.00102		0.18	
ATE_{mix}	100/0.00102 > 5 000 mg/kg		100/0.18 > 5 mg/litre	

The $\sum C_i/ATE_i$ for As (V) and Cu (II) by the inhalation route cannot be more than 0.18 (Table 10.4), and even less in the case of ingestion. Therefore, it is not surprising that substitution in the additivity formula yields an ATE_{mix} dose for ingestion and an ATE_{mix} air concentration for inhalation that are orders of magnitude higher than the upper ATE trigger limits for the oral (5 000 mg/kg) or inhalation (5 mg/litre) routes of exposure. Since the ATE_{mix} values are higher than the upper limit concentrations, classification of the bio-accessible exposure mixture as an acute toxicity hazard by either the oral or inhalation routes of exposure is not triggered. The trigger limits are available in the Purple Book Table 3.1.1 (UN 2021), according to which a lower ATE_{mix} indicates a more hazardous mixture.

Thus, it is concluded that the bio-accessible concentrations of any of the elements As (V), Cr (III) and Cu (II) are insufficient to result even remotely in an acute toxicity hazard to exposed persons.

<u>Skin and eye corrosion or irritation</u>
Cr (III) is not classified in any of these two hazard classes and only As (V) and Cu (II) are assessed.

According to the Purple Book, Tables 3.2.3 and 3.3.3, and without explaining the classification system in detail, the lowest classification limit concentration in any of the skin or eye corrosion or irritation hazard categories is 1 per cent. This limit is applicable to either a single classified ingredient in a mixture, or to the sum of concentrations of more than one ingredient in a mixture.

The sum of bio-accessible concentrations of As (V) and Cu (II) in treated Pine wood (Table 10.1), is 0.15, which is an order of magnitude lower than the lowest trigger limit concentration of 1 per cent.

Thus, it is concluded that the bio-accessible concentrations of any of the elements As (V), Cr (III) and Cu (II) are insufficient to result even remotely in a skin or eye corrosion or irritation hazard to exposed persons.

<u>Skin and respiratory sensitisation</u>
None of the elements are classified in these hazard classes and thus do not pose a sensitisation hazard to exposed persons.

<u>Specific target organ toxicants</u>
None of the elements are classified in these hazard classes and thus do not pose a specific target organ hazard to exposed persons.

Carcinogenicity
Only As (V) is classified as carcinogenic. The classification limit concentration for classification of a mixture with As (V) (carcinogenicity category 1) as a carcinogenicity hazard is 0.1 per cent (Purple Book, Table 3.6.1).

Considering the bio-accessibility concentrations of As (V) in both of the treated wood types (Table 10.3), it is clear that the concentrations are lower than the classification limit.

Thus, it is concluded that the bio-accessible concentrations of As (V) in both of the treated wood types are insufficient to pose a hazard of carcinogenicity to exposed persons.

Mutagenicity
None of the elements is classified in this hazard class. Thus, none of the assessed elements pose a mutagenicity hazard to exposed persons.

Reproductive toxicity
Only As (V) is classified as a reproductive toxicity hazard (category 2). The classification limit concentration for classification of a mixture with As (V) as a hazard to reproductive function is 0.1 per cent (Purple Book Table 3.7.1).

Considering the bio-accessible concentrations of As (V) in both of the treated wood types (Table 10.3), it is clear that the concentrations are lower than the classification threshold.

Thus, it is concluded that the bio-accessible concentrations of As (V) in both of the treated wood types are insufficient to pose a hazard to the reproductive function of exposed persons.

Aspiration hazard
Aside from the fact that the likely exposure scenarios are unlikely to involve any volumes of ingestion of solids relevant to an aspiration hazard, none of the elements is classified as aspiration hazards.

Conclusion
It is concluded that the bio-accessible concentrations of the elements As (V), Cr (III) and Cu (II) are insufficient to result, even remotely, in a health hazard to persons exposed simultaneously to these elements available for uptake from treated wood. This conclusion is based on the highest bio-accessible concentrations of the elements in any of the treated wood types. The conclusion is valid for all routes of exposure and for all health hazards considered in the GHS.

11 Current status of CCA as a timber preservative in North America

Registration review for chromated arsenicals in the USA started in 2015 (USEPA online a). USEPA conducts this registration review for all pesticides every 15 years to ensure that products can perform their intended functions without creating unreasonable risks to human health and the environment. In its Interim Decision ("ID"), USEPA implemented additional mitigation measures to protect workers who apply chromated arsenicals. Information is contained in the docket at EPA-OPP-2015-0349 (USEPA online b), which consists of 18 documents, of which the report with title "*Chromated Arsenicals and Dichromic Acid Interim Registration Review Decision Case Numbers 0132 and 5012*" (USEPA 2021) is the most pertinent. It has not been the purpose of the current INFOTOX study to review the USEPA docket in detail, but to identify the key aspects that have relevance in this INFOTOX evaluation.

In its introduction, USEPA (online b) explains that chromated arsenicals, *which include chromated copper arsenate (CCA), "are a group of pesticides containing chromium, copper, and/or arsenic that protect wood against termites, fungi and other pests that can degrade or threaten the integrity of wood products. Chromated arsenicals-treated wood is used to produce commercial wood poles, posts, shakes, shingles, permanent foundation support beams, pilings, and other wood products permitted by approved labelling*."

USEPA (online b) stated that chromated arsenicals pose cancer and non-cancer health risks of concern to workers in wood treatment facilities, but it "***did not find health risks of concern for the general public*"** (verbatim).

The statement that "*chromated arsenicals pose cancer and non-cancer health risks of concern to workers in wood treatment facilities"* was however challenged from several positions. In its response to Docket No EPA-HQ-OPP-2015-0349, the American Chemistry Council (ACC) Center for Biocide Chemistries Arsenical Wood Preservatives Task Force ("AWPTF" or "Task Force") asserted that USEPA significantly overstated occupational health risks due to issues with both the exposure and hazard calculations. Of specific concern was the approach taken in determining dermal exposure of inorganic arsenic and in the determination of the respirable fraction of aerosols. The ACC subcontracted Exponent to assist with the evaluation of the USEPA's health risk assessment approach. Exponent is a prominent and well-respected firm of toxicologists in the USA. The report of Exponent (Tsuji and Garry 2021) is presented in full as an annexure to the American Chemistry Council submission (ACC 2021a). INFOTOX had raised similar concerns about overstatement of risk in the evaluations of exposure of children at CCA-treated playsets in its 2014 report (Van Niekerk and Fourie 2014).

In another response to the docket, the American Chemical Council made recommendations for changes to the USEPA's ID about personal protective equipment (ACC 2021b).

Requests were made in response to the docket for assessing the use of CCA-treated wood in marine environments, and the phasing out of pentachlorophenol was welcomed. There was no single submission suggesting the phasing out of CCA in timber treatment.

The ID in the USEPA registration review for chromated arsenicals dealt with assessment of occupational health risks in the timber treatment industry, which was criticised as having overstated risk. Occupational health risks in this industry in South Africa are adequately managed under the Regulations for Hazardous Chemical Agents, 2021, as summarised in Section 4 above.

12 Rationale for invoking the precautionary principle

Generally, the initiative to limit public exposure to chemicals that meet the criteria of carcinogenicity, mutagenicity, and reproductive toxicity (CMR) categories 1A or 1B under the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), is understood and supported. Note that at this point the argument is about hazards in the CMR category according to the GHS, but the deciding factor should be demonstration of the likelihood of risk. The fact that a material or product contains arsenic does not, itself, mean that there is a risk to the public. The toxicity of arsenic is not argued, but an intact route of exposure to the receptor must be available in order for the hazard to result in a health risk. There is no purpose in removing a material or product from society if, firstly, its presence does not indicate a route of exposure and, secondly, such removal will not reduce risk in any way.

Any decision to implement precautionary measures needs to be justified by more than pointing at the possibility that a risk may exist. The decision to prohibit manufacture and use of a formulation such as CCA requires evidence that public exposure to arsenic will decrease because of this prohibition, and most importantly, a structured and transparent procedure must exist for quantifying this evidence (Schütz and Weidemann 2005).

Members of the public are exposed to elevated levels of inorganic arsenic through drinking contaminated water, using contaminated water in food preparation and as a result of food chain contamination through irrigation of food crops, industrial processes, and smoking tobacco. Fish, shellfish, meat, poultry, dairy products and cereals may be dietary sources of arsenic, although exposure to arsenic from these foods is generally lower compared to exposure through contaminated groundwater. In seafood, arsenic is mainly found in a less toxic organic form (WHO online a).

The significance of arsenic exposure through consumption of food is illustrated in the results of a chronic dietary study by the European Food Safety Authority published (Arcella et al. 2021). A total of 13 608 analytical results on inorganic arsenic (iAs) were considered in the assessment, with 7 623 corresponding to drinking water and 5 985 to different types of food. Samples were collected across Europe between 2013 and 2018. It is not the purpose of this INFOTOX report to comment in detail about arsenic exposure through food intake, but it should be noted that the highest dietary exposure to arsenic in this study was estimated in the young population (infants, toddlers and other children). Tsuji et al. (2007) confirmed that the very small potential exposure from contact with CCA-treated wood is far below and indistinguishable from the background levels from diet and drinking water in US populations.

There is also no defensible reason to phase out CCA in wood treatment because of the presence of Cr (VI) in CCA. Cr (VI) is widely used in electroplating, stainless steel production, leather tanning and textile manufacturing (NIH online), all of which materials are widely in day-to-day use. It has been demonstrated in Section 8.2 that Cr (VI) is reduced in wood following impregnation and there is a standard compulsory diphenyl carbazide test for assessing complete reduction of Cr (VI) to Cr (III) in the CCA fixation process.

13 Conclusions

13.1 Focus on arsenic

The intention of the Registrar to "*prohibit the use of ingredients and their formulations that meets* (sic) *the criteria of CMR categories 1A or 1B of the GHS as from 01 June 2024*" should be interpreted in terms of reducing risks to human health, i.e., leading to health benefits. With regard to this INFOTOX report, arsenic is the chemical of interest. Hexavalent chromium, which is carcinogenic and mutagenic, in not relevant in CCA-treated timber, as Cr (VI) is reduced to Cr (III) in the fixation process following impregnation of the wood, as described in Section 8.2 of this INFOTOX report. Copper is not in the CMR category and is thus not of concern in this discussion.

13.2 Dietary exposure to arsenic

Considering that exposure of the general population to arsenic is primarily through water and food (Arcella et al. 2021; Shalat et al. 2006; Lew et al. 2010; Van Niekerk and Fourie 2014), reducing health risks through this anticipated prohibition by the Registrar should be best achieved through reducing dietary exposure to arsenic, if possible.

The WHO, in collaboration with the Food and Agricultural Organization of the United Nations ("FAO"), is responsible for assessing the risks that pesticides pose to humans. Both direct exposure and exposure through residues in food are considered, and recommendations are made for adequate protection (WHO online b)

Risk assessments for pesticide residues in food are conducted by the Joint FAO/WHO Meeting on Pesticide Residues ("JMPR"), an independent, international expert scientific group. Assessments are based on all data submitted for national registrations of pesticides worldwide, as well as on scientific studies published in peer-reviewed journals. The JMPR then establishes limits for safe intake of a pesticide from residues in food, to ensure that the amounts of pesticides that people are exposed to through consuming food over their lifetime will not result in adverse health effects (WHO online b).

These acceptable daily intakes of pesticides in food are applied by governments and international risk assessment bodies, such as the Codex Alimentarius Commission (the intergovernmental standards-setting body for food), to establish maximum residue limits ("MRLs") for pesticides in food.

Although it is understood that there is a margin of safety in setting the MRLs, there may be motivation to reduce risks even further, to a level that is as low as reasonably achievable, especially for pesticides in the CMR categories used in agriculture, where food commodities are affected. Such considerations should always be risk based, taking into account that pesticides in agriculture play a critical part in optimising the quality and production rates of commodities, thus playing a vital role in assuring food security.

13.3 Context of CCA-treated timber

CCA has been used across the world as a wood preservative since the middle 1930's. An effective wood treatment formulation must meet several important criteria (Lebow 2004). The primary difficulty is to identify a combination of active ingredients that will provide long-term protection against a wide range of organisms that damage wood. The preservative must protect against damage by termites, carpenter ants, beetles, other insects, and decay fungi. Even within the group of decay fungi there is a range of species and strains that differ in chemical tolerance. These requirements preclude the use of compounds that are effective in protecting wood against a limited number of organisms. Validation of a formulation requires field trials under different climatic conditions over periods of several years. It is thus not easy to find alternative wood treatment formulations that are as effective as CCA, and do not pose environmental risks through leaching. Therefore, there have to be compelling reasons to prohibit use of CCA formulations as wood preservatives.

The logic of reducing dietary exposure to arsenic cannot be applied in prohibiting CCA in timber treatment because of active ingredients that meet the criteria of CMR categories 1A or 1B. Arguments about public health risks associated with CCA-treated wood are not convincing, as this INFOTOX report has demonstrated unambiguously. INFOTOX also described the limited bio-accessibility of arsenic from CCA-treated wood, where CCA is fixed as a preparation in the wood. Multiple credible scientific references have confirmed that the very small potential exposure to arsenic from contact with CCA-treated wood is far below and indistinguishable from the background arsenic levels from food and drinking water. INFOTOX highlighted in a previous report that restrictions on the use of CCA-treated timber for certain applications were based on invoking the precautionary principle (Van Niekerk and Fourie 2014).

Any decision to implement precautionary measures needs to be justified by more than pointing to the possibility that a risk may exist. The decision to prohibit manufacture and use of a formulation such as CCA requires evidence that public exposure to arsenic is elevated as a result of the use of this preparation in treating timber, and that public exposure will decrease because of this prohibition. Most importantly, a structured and transparent procedure must exist for quantifying this evidence. It is clear from this INFOTOX review of a large volume of scientific information on this topic that evidence of an increase in public health risks as a result of the use of CCA in timber is lacking, and a decrease in public exposure to arsenic as a result of prohibiting the use of CCA in timber treatment will be impossible to demonstrate.

The various sections in this INFOTOX report should be considered holistically. Evaluation of the use of CCA as a timber preservative in the EU, USA and elsewhere, as referred to in this report, and assessment of multiple scientific reports on the matter, confirm that CCA represents an **exceptional case** in considering prohibition in its use. CCA is a superior formulation in preserving wood in various outdoor applications and is effective for over 30 years. As described in South African National Standard SANS 1288 (Section 6.2 of this report), economic losses due to adverse impacts on wood in the absence of treatment with a preservative are considerable. SANS 1288 also stated that some of the treatment formulations are ineffective for the given hazard conditions. Considering the implausible notion that prohibiting CCA in wood treatment would lead to health benefits, it will not be in the public interest to prohibit the use of CCA in timber treatment.

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